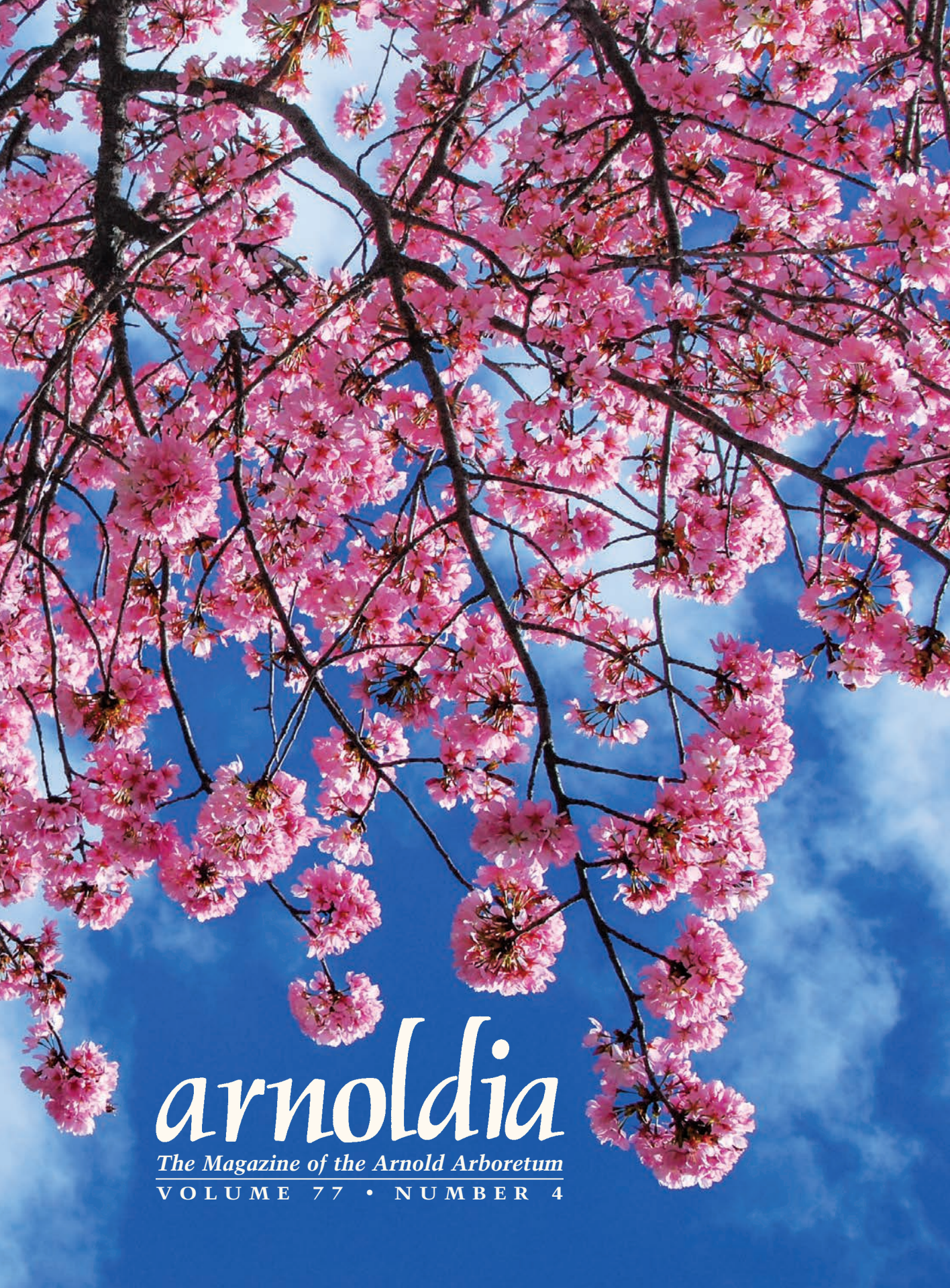

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The Magazine of the Arnold Arboretum

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QUERCUS heterophilla.

Bartram's Oak

arnoldia

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The ARNOLD ARBORETUM of HARVARD UNIVERSITY

CONTENTS

Front and back cover: Sargent cherry (*Prunus sargentii*) was named, in 1908, in honor of Charles Sprague Sargent, the first director of the Arnold Arboretum. Ten years later, Sargent sent nursery stock of this Japanese ornamental to Henry F. du Pont, who planted the species at what is now Winterthur Museum and Gardens. Photo at the Arnold Arboretum (accession 794-28*B) by Meng Li.

Inside front cover: Pancrace Bessa illustrated the Bartram oak (*Quercus* × *heterophylla*) for the second volume of François André Michaux's *Histoire des Arbres Forestiers de l'Amérique Septentrionale,* published in 1812. Although Michaux named the taxon *Quercus heterophylla,* the label on the illustration is curiously misspelled. Image from Biodiversity Heritage Library.

Inside back cover: Bud scales of the shagbark hickory (*Carya ovata*) become dramatic centerpieces in spring. Very occasionally, the trees produce a structure that shares characteristics with both a bud scale and a photosynthetic leaf (bottom, second from right), which shows the relationship between the two leaf forms. Photos and composition by Kristel Schoonderwoerd.

Uncommon Gardens

Ben Goulet-Scott

With one last gulp of iced tea, I stepped out of a rented sedan onto the weedy shoulder of Forest Service Road 117 to perform my pre-fieldwork ritual. I tucked my pants into my socks, applied sunscreen and bug spray, and pressed a baseball cap over my spiky bed head. The morning temperature in western Kentucky was already approaching 90°F (32°C), unusual for late April. I grabbed my water bottle and tablet from the back seat and turned towards my experimental garden plot, which was planted with three subspecies of pink-flowered herbaceous *Phlox*. As a doctoral student working with Robin Hopkins, a faculty member at the Arnold Arboretum, I have returned regularly to western Kentucky and Tennessee to study the role of local adaptation in the divergence and speciation of these closely related lineages.

A skeletal dead tree stood on the opposite side of the field, a favorite perch for large birds. I recognized the familiar broad-shouldered silhouette and gleaming white head of an adult bald eagle. Surely it had long since noticed me and my car, and as I pushed through the tall grass to arrive at my modest garden, I wondered if I might now be familiar to the eagles of this area. I was relieved to find that my plants still stood, and in fact, they seemed to be thriving. The spring before, in 2018, I had worked with Robin and lab technician Matt Farnitano to plant 321 rooted cuttings at this site, each no more than four inches tall. Now many of the plants boasted dozens, even hundreds, of bright pink flowers. I set down my water bottle and turned on the tablet, ready to record herbivore damage and count flowers for as long as the daylight permitted.

This plot is a type of experiment known as a common garden. Three different taxa—*Phlox pilosa* subsp. *pilosa*, *P. pilosa* subsp. *deamii*, and *P. amoena*—had been planted in a random order, and because the growing conditions are consistent, any differences in traits among the three taxa can be ascribed to genetic differences rather than plastic responses to the environment. Common garden experiments have a rich history in plant biology. Botanists in the first half of the twentieth century (especially Göte Turesson, Jens Clausen, David D. Keck, and

GOULET-SCOTT, B. 2020. UNCOMMON GARDENS. *ARNOLDIA*, 77(4): 2–5

William Hiesey) made foundational contributions to our current understanding of heritable variation in natural populations using common gardens. Outside the Weld Hill Research Building at the Arnold Arboretum, other researchers are using a series of common garden plots to study the ecology, morphology, and physiology of woody plants. In fact, the entire Arnold Arboretum can be viewed as a large common garden, with plant species and varieties from around the world growing in one location.

My research in Kentucky required not one but three common gardens, one in each habitat of my three study taxa. During the summer of 2017, I had traveled throughout the native ranges of these three subspecies in the southeastern United States and collected plant material for the gardens. Perennial *Phlox* propagate well from cuttings, so I collected single stems from wild plants, leaving the rest of the plant in the ground. I mailed these stems back to labmates at the Weld Hill Research Building who planted them in soil so they would produce roots. After one year in the Weld Hill greenhouses, they furnished three cuttings each, allowing me to plant a genetically identical panel of cuttings in each garden. All three of my common gardens sit adjacent to a wild population of one of the three subspecies. This experimental design—plant all taxa in all habitats—is called a reciprocal transplant. I repeated any measurements taken in this garden in the other two, both within a couple hours' drive.

A reciprocal transplant is a powerful test for local adaptation. Populations that are adapted to different ecological niches are unlikely to encounter each other in their distinct habitats, and if they do, the nonlocal taxon is likely maladapted and will not persist. Local adaptation, therefore, may contribute to the divergence of closely related lineages. In general, *Phlox pilosa* subsp. *pilosa* favors open grassy areas in full sun, while *P. amoena* grows in the grassy fringes of mixed hardwood forest, and *P. pilosa* subsp. *deamii* peppers the understory of similar forest edges. But because the ecological factors that differentiate the preferred habitats of my three *Phlox* taxa are multidimensional and not entirely obvious to my human senses, I let the wild populations guide me to appropriate sites for the experiment.

Settling into my morning work routine, I opened a spreadsheet on my tablet that contained a stack of three-digit codes in a column on the left. Each code corresponded to a unique plant identifier that was stamped into an aluminum tag and fastened in the ground at the base of each plant. In order to test for local adaptation, I designed my experiment to evaluate traits related to fitness, like susceptibility to herbivore damage and total reproductive output. My goal on this visit was to score the presence or absence of herbivore damage and count the number of open flowers on every plant. I labeled two new columns ("herbivory_2" and "flowers_2") and eased into a cross-legged seat on the edge of my plot.

Collecting these data was a comprehensive sensory experience. As I pushed and pulled inflorescences aside to reveal more clusters of bright pink, my fingers reluctantly harvested the sticky secretion that protects the flowering branches of *Phlox pilosa* subsp. *pilosa.* Each time I agitated a bunch of flowers, a small flare of sweet fragrance mixed with the sharp scent of spring grasses and forbs soaking in the midmorning sun. The exaggerated buzz of a carpenter bee hummed under the exclamations of chattering songbirds. A jumping spider tickled across my wrist. Sitting quietly, eye-level with the asters (*Erigeron philadelphicus*), I immersed myself in the dense fabric of interactions that contributed to the deceptively neat figures in my spreadsheet.

This common garden, in the full-sun habitat of *Phlox pilosa* subsp. *pilosa,* is tucked into the northern tip of a 170,000-acre inland peninsula (the largest in the United States), which spans the border between Kentucky and Tennessee. When the Tennessee Valley Authority completed the two dams that isolated this strip of land, aptly named Land Between the Lakes, the residents were forced to move, leaving their properties to be reclaimed by mixed hardwood forest. The house that complemented this yard and surrounding fields has long since been

Facing page: **Intermixed *Phlox* subspecies flower in the author's common garden in the Land Between the Lakes region of western Kentucky.**

ALL PHOTOS BY THE AUTHOR

Each *Phlox* in the author's common garden is identified with a numbered aluminum tag, staked at the base.

demolished, but a patch of feral bearded irises (*Iris* × *germanica*) and a single mature post oak (*Quercus stellata*) hint at where it once stood. These days, the property is mowed annually and burned periodically by the United States Forest Service as part of a scattered network of restored prairie patches, important habitat for the robust deer and turkey populations in this National Recreation Area. My research permit with the local Forest Service office, however, guaranteed that this field would not be burned from spring 2018 through fall 2020, and my garden plot, demarcated with pink marking flags, would not be mowed.

The *Phlox* that I study are the hangers-on of a much more audacious long-term experiment—the conversion of southeastern prairie into farm and forest. Through the conversion into farmland, suppression of fire, and elimination of grazing bison, humans removed the sources of periodic disturbance that once precluded large trees and favored communities of resilient herbs and grasses. These changes have been compounded by the ebb and flow of fertilizer and pesticide use, an evolving system of hunting regulations, and a rapidly changing climate, creating a volatile experiment with few constant variables. Each species has borne witness to the arc of human impact in its own way. The bald eagle, once suffering, now thrives. The same is true for white-tailed deer and wild turkey. Free-ranging bison have not returned, but Land Between the Lakes supports two small populations of reintroduced bison that graze on fenced-off grasslands, an allusion to the millions that roamed widely until the early 1800s. Dozens of species of prairie-dwelling plant have retreated to small patches of suitable habitat and are threatened or endangered. Today, the closest approximation to the lost prairie disturbance regimes is often the roadside, periodically grazed by a fleet of Department of Transportation mowers. These parallel ribbons are precious refugia for what remain of the remnant prairie species in this part of the world, including the *Phlox* that I study.

In the Southeast, many grassland species, including the three types of *Phlox* studied by the author, are confined to roadside strips.

Research on the presence and strength of local adaptation may be especially relevant as humans continue to modify the environment. As the southeastern prairies shrank, these three *Phlox* withdrew into smaller and smaller patches of suitable habitat. If the *Phlox* were forced into shared fragments, their chances of contacting one another, hybridizing, and melting into one shared gene pool likely increased. Yet, with the exception of a half mile of roadside in western Tennessee, I have never found any of my study taxa living together. After my initial round of spring observations, I would return to these bustling common gardens every few weeks to track flower output as well as the number of fruits each plant produced, the number of seeds in a subset of those fruits, and the aboveground biomass at the end of the growing season. These traits quantify survival, growth, and reproduction, all aspects of fitness that would allow me to test my prediction that these subspecies are locally adapted to distinct ecological conditions. If so, it would help explain how they kept their ecological distance, even as they were concentrated into small pockets of prairie-like habitat.

By seven o'clock, the tall grass around me glowed pink. The yellowthroats and gnatcatchers resolved their conversation for the day, and I strained to distinguish the *Phlox* flowers from one another. I had counted more than six thousand flowers on about two-thirds of the plants in the garden—a tedious but satisfying task—and would finish the rest before the next day's lunch. I gathered my water bottle and tablet and swished back through the tall grass. Standing next to the rental car, I shook off the tunnel vision of counting flowers and let my eyes wander over the rolling field. My gaze landed again on the large dead tree. A bald eagle leapt from an upper branch, circled the field once, and slipped out of sight behind the canopy.

Ben Goulet-Scott is a doctoral candidate in the Department of Organismic and Evolutionary Biology at Harvard University and a fellow of the Arnold Arboretum.

ANDREW CROWL

Revisiting the Mystery of the Bartram Oak

Andrew Crowl, Ed Bruno, Andrew L. Hipp, and Paul Manos

An impressive oak tree grows on the quad of West Chester University, outside of Philadelphia. It is a healthy, open-grown individual measuring approximately 110 feet (33.5 meters) tall and with a trunk diameter of 64 inches (1.6 meters) at breast height. As the oldest tree on campus, it has become an important landmark for students. The tree is also a putative descendant of the first-described Bartram oak (*Quercus* × *heterophylla*) and is the largest of its kind in Pennsylvania. As such, the tree was recently recognized as a state champion, but this title remained somewhat uncertain, given the perplexing taxonomic status of the Bartram oak.

Ed Bruno, the landscape designer at West Chester University, has been working with the trees on campus for more than thirty years. Bruno was aware of an 1862 observation by the southeastern naturalist Samuel Buckley, indicating that the West Chester oak was perhaps a second-generation descendant of the original Bartram specimen—a seedling of a seedling. The original tree, however, is long gone, which meant that the West Chester oak—now approximately 170 years old—could not be directly compared to it. For Bruno, the identity of the tree became increasingly frustrating.

To provide some clarity, Bruno contacted a dozen or so oak taxonomists in 2015, requesting their opinion of the tree's hybrid status and possible ancestry. He shared images of leaves, twigs, buds, bark, and acorns. Most recipients responded with slightly different opinions but agreed the tree was of hybrid origin. The varied answers, however, left the identity in ongoing limbo. Paul Manos, professor of biology at Duke University, agreed with the current identification of the specimen as a possible Bartram oak but suggested DNA testing would be necessary for verification. Testing would also provide an exciting opportunity to finally check hypotheses regarding the putative parents of this famous tree. The results would shed light on a two-hundred-year-old botanical mystery and further the narrative of hybridization as a frequent and important phenomenon in oaks.

CROWL, A., BRUNO, E., HIPP, A., AND MANOS, P. 2020. REVISITING THE MYSTERY OF THE BARTRAM OAK. *ARNOLDIA*, 77(4): 6–11

History of the Bartram Oak

The original Bartram oak grew near Philadelphia, on the west bank of the Schuylkill River. In the mid-eighteenth century, the tree caught the eye of John Bartram, who was among the first practicing Linnaean-era botanists in the American colonies. Bartram traveled extensively throughout eastern North America, cataloguing and collecting native plants. While the anomalous oak, located within walking distance of Bartram's home, resembled known oak species of the region, it possessed distinct—though somewhat ambiguous—morphological attributes, such as irregular lobing of the leaves and a range of leaf types from unlobed to lobed. This form of variation is termed heterophylly and likely prevented the specimen from being formally classified for another half century.

In 1802, French botanist François André Michaux traveled to Philadelphia where he met with John Bartram's son, William Bartram, an accomplished botanist and naturalist in his own right, who was maintaining and growing his father's botanical collection. During this visit, Michaux presumably observed the tree for the first time. When Michaux formally named *Quercus heterophylla*—coining the common name Bartram oak—in his North American silva, published in 1812, he designated the taxon as a new species rather than a hybrid. Michaux described the morphological ambiguity and suggested that although the Bartram oak resembled the laurel oak (*Q. laurifolia*), the leaves of that species were never lobed and the closest known population was more than one hundred miles from Philadelphia.

The newfound species status bestowed upon the Bartram oak, however, was quickly called into question, in 1814, by Pennsylvanian botanist Frederick Pursh, who had previously served as a horticultural manager at a neighboring estate, known as the Woodlands. "Of this singular species there is but one individual known, which grows on the plantation of the Messrs. Bartrams near Philadelphia," Pursh wrote. "It probably is only a hybrid plant on that account, and cannot with propriety be considered a genuine species." This first suggestion of a hybrid origin was followed by one hundred years of confusion and arguments between botanists as to the validity of this taxon as a distinct species, its hybrid status, and its potential parents.

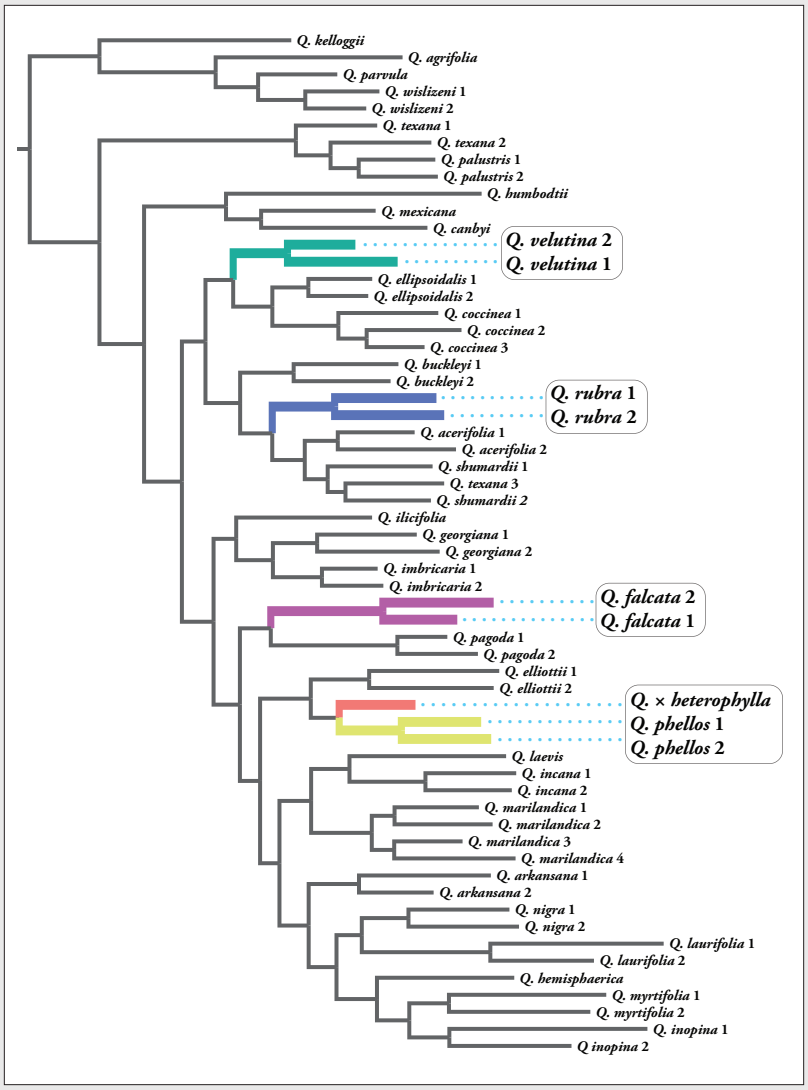
Tragically, in 1842, almost two decades after the death of William Bartram, botanist Thomas Nuttall reported that the original tree had been recently cut down. Thomas Meehan, a preeminent American horticulturist, added to this report in 1853, noting that the tree had been removed because it "interfered with a view of the Schuylkill [River] from the Woodlands." However, acorns of the tree had been collected before the removal and planted on the property and elsewhere around Pennsylvania. In subsequent years, numerous additional examples of this taxon were discovered in New Jersey, Delaware, Maryland, and New York. Though the infamous tree had been lost, this was not the end of the Bartram oak—as a lineage or a botanical mystery.

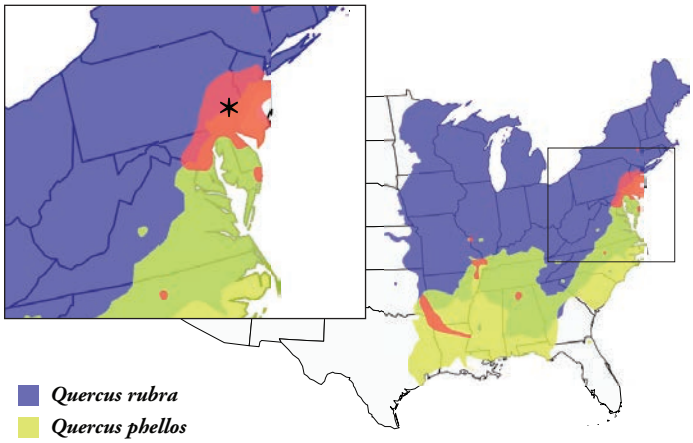
By the mid-1800s, seemingly every notable American botanist, and many from abroad, had examined either an herbarium specimen of a Bartram oak or an actual tree. But the debate continued, and in the words of botanist Arthur Hollick, looking back on this taxonomic foment in 1919, "The opinions expressed in connection with [the Bartram oak] were as diverse and heterogeneous as the trees were heterophyllous." During this period, the Bartram oak was identified by various experts as *Quercus ambigua, Q. phellos, Q. imbricaria, Q. laurifolia, Q. hemisphaerica, Q. coccinea, Q. leana, Q. tinctoria* (or *Q. velutina*), *Q. aquatica* (or *Q. nigra*), *Q. palustris,* or some combination of these.

A trend did begin to emerge, however, during the latter half of the nineteenth century: the Bartram oak was clearly aligned, in some way, with the willow oak (*Quercus phellos*). This was based primarily on leaf morphology, with the willow oak exhibiting unlobed and entire leaf margins. Some authors believed the Bartram oak to be a lobed form or variety of the willow oak; others maintained that it was simply an anomalous willow oak specimen; and others (perhaps the majority) argued for a hybrid origin in which the willow oak was a parent. The second parent continued to be debated.

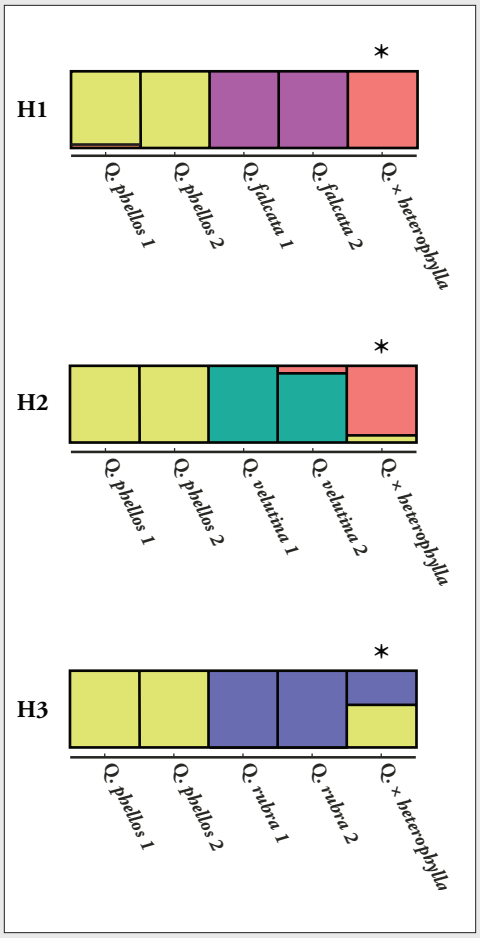
Among those that subscribed to the hybrid hypothesis were famed botanists Asa Gray and George Engelmann. Gray, in 1863, expressed

Facing page: **The Bartram oak (*Q.* × *heterophylla,* center) displays a range of leaves. Some resemble the willow oak (*Q. phellos,* top left); others resemble the northern red oak (*Q. rubra,* top right). These samples are from Duke Gardens.**





Evolutionary relationships of red oaks (*Quercus* section *Lobatae*) are rendered on a phylogenetic tree (left), showing the clear affinity between the Bartram oak and the willow oak (*Q. phellos*). This complements results from genetic clustering analyses of the Bartram oak and its hypothesized parent species (below). Each colored box represents an individual tree, with colors indicating the genomic composition of that individual. For H1 and H2, the Bartram oak is distinct from the other species tested, while in H3, the genomic content of the Bartram oak demonstrates a clear combination of *Q. phellos* and the northern red oak (*Q. rubra*). The map shows the distribution of the Bartram oak and its putative parent species. A black star indicates the location of the West Chester oak.



the opinion that the Bartram oak was a hybrid between the willow oak (*Quercus phellos)* and black oak (*Q. tinctoria,* now *Q. velutina*). Engelmann, on the other hand, disagreed with this and argued, for a time, that the Bartram oak should be considered a distinct species. By 1877, however, he had clearly aligned his thinking with Gray, though he disagreed as to the second parent species: "While I was long inclined to follow Michaux in considering it as a distinct species … That it is a hybrid is most probable," Engelmann wrote. "One of its parents is undoubtedly *Phellos;* for the other we must look among the lobe-leaved Black-oaks of its neighborhood, *falcata, rubra* or *coccinea,*" meaning the southern red oak, northern red oak, and scarlet oak, respectively.

At long last, in 1905, nearly one hundred years after Michaux's recognition of the Bartram oak, a group from the New York Botanical Garden attempted to put the debate to rest, once and for all. Arthur Hollick, then the assistant curator of the garden, later reported that seventy-five acorns from a tree on Staten Island had been collected and propagated to test the hybrid hypothesis. The resulting seedlings exhibited considerable variation in leaf morphology, which could be arranged in a series according to the extent of their lobing. On one end of the spectrum were trees exhibiting the deep-lobed leaves of northern red oak (*Quercus rubra*), while others had narrow leaves with entire margins, similar to those of willow oak (*Q. phellos*). The remaining individuals were heterophyllous trees, exhibiting various combinations of red and willow oak leaf forms.

This was convincing evidence that the two parents for the Bartram oak were *Quercus phellos* and *Q. rubra,* and for a long time, this was the only hard evidence regarding the identity of the hybrid. But over one hundred years after this New York Botanical Garden study—and two hundred years after Michaux's account was first published—we reopened the case. This time, however, we had access to DNA sequencing technologies and computational methods, allowing us to peer into the genomes of these trees and directly observe the genetic composition.

Modern Investigation

In an attempt to shed light on the identity of the West Chester tree—and to provide insights into the background of the original Bartram oak—we broadly sampled North American red oaks, including any species hypothesized to be involved in the hybrid history. We also collected material from the West Chester tree. We then used a genomic sequencing technique (restriction site-associated DNA sequencing or RADseq) to create a genetic dataset for these taxa, resulting in tens of thousands of informative DNA sites for downstream analyses.

Based on these data, evolutionary relationships were visualized with a phylogenetic tree. Much like a family tree, a phylogeny is a diagram depicting a pattern of descent and relationships between organisms. It is important to note that the behavior of hybrids in phylogenies is not straightforward and often results in one of two outcomes: the hybrid may be found as a close relative to one of the parent species, or it will be placed in an intermediate position in the tree, falling somewhere between the two parent species. Our phylogenetic analyses confirmed a close relationship of the Bartram oak with willow oak (*Quercus phellos*).

We then carried out additional DNA analyses using a clustering approach that groups individuals based on DNA similarities and differences. This technique can be used to infer the presence of admixed individuals (those whose genomes are a combination of different parent species). Based on previous assertions and our own morphological insights, we tested three plausible hypotheses regarding possible parental lineages: willow oak crosses with southern red oak (*Quercus falcata*), black oak (*Q. velutina*), and northern red oak (*Q. rubra*). Our clustering analyses indicated the genome of this specimen is a mosaic, suggesting a hybrid origin, with northern red oak (*Q. rubra*) as the probable second parent. This confirmed morphological observations of the 1905 New York Botanical Garden study, as well as our own detailed observations.

The West Chester oak shows many fruit characteristics similar to *Quercus rubra.* Fruit size is larger than would be expected given any of

the other potential parents, measuring up to 1.2 inches (30 millimeters) in length, consistent with the large nuts of *Q. rubra.* The cup covering of the nut also suggests *Q. rubra* as a likely parent: while the cup of this taxon covers approximately one-quarter of the nut, *Q. velutina* and *Q. falcata* both possess cups that cover up to one-half of the nut. Cup scale arrangement is consistent with *Q. phellos* and *Q. rubra,* both of which have smooth and tightly appressed scales. Bud size and bud scales are also consistent with *Q. rubra.* Leaf pubescence is reminiscent of *Q. phellos,* which presents hairs early in development but becomes glabrous to sparsely pubescent later in the season. Late-season leaves of the West Chester oak are mostly glabrous, with tufts of hairs in the axils of veins on the underside, much like *Q. rubra* leaves, which are glabrous throughout development but with similar tufts of hair. Moreover, the bark of the Bartram oak is reminiscent of *Q. rubra,* with smooth patches on the trunk.

This hybrid scenario for the Bartram oak is plausible given the overlapping distributions of willow oak and northern red oak at the edges of their current ranges in eastern North America. As the West Chester tree is likely a second-generation offspring of the original Bartram oak, we propose the West Chester tree is the result of backcrossing with willow oak, a common element of the forest in the Philadelphia area.

Conclusions and Broader Implications

Many questions remain about the Bartram oak due to the inclusion of only a single individual in this study, but the interaction between the two parent species is clear. The parents share only a narrow range of ecological space, yet numerous hybrid individuals have been reported from the northern edge of the willow oak (*Quercus phellos*) range, distributed in disparate patches. This pattern is likely facilitated by an expanded distribution of willow oak due to land conversion during the last two hundred years, creating increased opportunities for the natural formation of *Q.* × *heterophylla.*

While we were unable to test whether all Bartram oaks are descendants of a single hybridization event, we believe it to be unlikely. Known Bartram oak specimens are often found as single individuals. In fact, a putative Bartram oak was recently identified by Paul Manos within Duke Gardens, on the campus of Duke University, after years of being noted as an anomaly by garden staff. This single eighty- to ninety-year-old tree occurs, along with both parent species, on the edge of the garden in an area that was historically forested. This suggests the Duke individual is a naturally occurring hybrid rather than an intentional planting. We posit Bartram oaks are the result of multiple independent events that have occurred repeatedly. Future studies with increased sampling will be needed to directly test this hypothesis.

Hybridization is certainly a common phenomenon in oaks; however, past concerns of oaks failing to form genetically coherent entities that merit species status have not been substantiated by genetic data. Based on recent DNA studies, we know that oak species have originated by diverging from one another *in spite of* gene flow. Oak hybrids are known to be fertile, and may eventually participate in forming narrow genetic bridges between species and generating new genetic combinations. This view of species as potentially open systems is based on observations made by generations of botanists. As more organisms across the tree of life are studied, the zoocentric definition of species as reproductively isolated end products of evolution is beginning to fade into history. This new paradigm redirects the question of species status to instead consider the evolutionary potential of naturally occurring Bartram oaks and the role of hybridization, in general, as oaks continue to respond to rapidly changing climates and landscapes.

The West Chester oak, in its relative isolation as a prized campus monument, is unlikely to contribute to this evolutionary continuum of gene swapping. But in natural populations, hybridization is no doubt playing a role in shaping the genetic architecture of future generations of trees. For now, and to satisfy those who need to classify and at the same time honor our rich botanical heritage, it seems fitting (and useful) to recognize all first- and later-generation hybrids of *Quercus phellos* and *Q. rubra* that show intermediate morphological qualities

ED BRUNO

The Bartram oak on the campus of West Chester University retains its claim as a state champion.

as Bartram oaks (*Q.* × *heterophylla*). And in the meantime, the champion West Chester tree remains a noteworthy destination for anyone with horticultural wanderlust.

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Andrew Crowl is a postdoctoral associate at Duke University. Ed Bruno recently retired as landscape designer at West Chester University, after a thirty-year career with the school. Andrew Hipp is senior scientist in plant systematics and herbarium curator at the Morton Arboretum. Paul Manos is a professor in the Department of Biology at Duke University.

Collector on a Grand Scale: The Horticultural Visions of Henry Francis du Pont

Carter Wilkie

In 1924, the Arnold Arboretum's first director, Charles Sprague Sargent, named a new hybrid buckeye, *Aesculus* × *dupontii,* in the *Journal of the Arnold Arboretum* and praised the tree's namesake, the du Ponts, for making the vicinity of Wilmington, Delaware, "one of the chief centers of horticulture in the United States." The family's fortune had exploded from the manufacture of gunpowder in the nineteenth century and was enriched further by chemicals in the twentieth. The resources the du Ponts dedicated to their landscapes made Delaware's Brandywine Valley a must-see destination for horticulturists who travel there to visit and study at the estates that are open to the public today.

Longwood Gardens, just over the Delaware border in Kennett Square, Pennsylvania, is the most visited, with its Italianate and French neoclassical fountains, lightshows, and fireworks that elicit audible "oohs" and "ahhs" from large crowds at all seasons of the year. Its creator, Pierre S. du Pont, was inspired by the spectacle and sense of wonder he experienced, at age six, when he attended the Centennial Exhibition in Philadelphia in 1876. His grand conservatories of hothouse plants continue to wow his posthumous guests, especially when decorated for Christmas, as does a garden amphitheater that hosts evening concerts and Shakespeare plays performed in a veritable Forest of Arden. Closer to Wilmington, his cousin Alfred I. du Pont spent a large fortune to build Nemours, with gardens modeled after Versailles. And Mt. Cuba, the estate of Lammot du Pont Copeland and his wife, Pamela, would become a display garden and research center for studying the native flora of the Piedmont.

Of the estates that earned northern Delaware the sobriquet "chateau country," Henry Francis du Pont's Winterthur Museum and Gardens is the most naturalistic. Home to nearly a thousand acres of rolling meadows, forests, and one of the finest woodland gardens in the world, Winterthur's connections to the Arnold Arboretum are deep. To walk the curving pathways through its woods and fields is to see a landscape shaped by what H. F. du Pont learned in Boston and through collaboration with the Arboretum's collectors and propagators over decades.

In an affectionate yet frank book about Winterthur (pronounced "winter tour," meaning "winter's door"), H. F. du Pont's daughter Ruth Lord claimed that her father found his life's calling at the Arboretum. As a student in his junior year at Harvard, in 1901, du Pont applied for admission into classes at Harvard's Bussey Institution, one of the first formal university programs to teach horticulture in America. Its mission, according to the *Bulletin of the Bussey Institution,* was to educate "young men who intend to become practical farmers, gardeners, florists, or landscape gardeners," as well as "men who will naturally be called upon to manage large estates." Young du Pont was destined to become all of those things. But by October, the fall semester had already begun. He was late and had an unimpressive academic transcript. The coursework was rigorous, taught by scientists with little patience for dilettantes. Still, he was admitted with the expectation that he could catch up. He wrote to his mother of his "sudden resolution … my great desire to really know something about flowers … In fact flowers etc. are the only real interests I have." He added, "I do not think I am impulsive I hope not at least. I merely think it is the smouldering [sic] of latent thought which has burst into flame." In his first course, Horticulture I,

Facing page: **The sweeping and naturalistic landscape of Winterthur Museum and Gardens was shaped by the horticultural vision of Henry Francis du Pont.**

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ARNOLD ARBORETUM ARCHIVES

Du Pont studied horticulture at Harvard's Bussey Institution, which was located on South Street, adjacent to the Arnold Arboretum.

taught by Benjamin Marston Watson, who led Harvard's horticultural instruction program for almost forty years, du Pont received a D-. The student would turn out to be a late bloomer.

From that unpromising beginning, H. F. du Pont went on to become one of the most accomplished horticulturists of the twentieth century, a man the Garden Club of America in 1956 designated as perhaps "the best gardener this country has ever produced" up until that time. He also served as an important benefactor of the Arboretum and would consult with its staff over the next seven decades.

Scion of a Distinguished Family Tree

H. F. du Pont (or "Harry," as his family called him) was born in 1880, "with a silver trowel in his hand." He was the son of Henry Algernon du Pont, the richest man in Delaware; grandson of Henry du Pont, the longest-serving chief executive of the E. I. du Pont de Nemours Company; and great-grandson of the company's founder, Éleuthère Irénée du Pont, who arrived in America with three generations of du Ponts in 1800. E. I. du Pont settled his family and established his powder works on the bank of Delaware's Brandywine River. There, at what he named Eleutherian Mills, he laid out a French *parterre,* with fruit orchards and *potager* to feed his family. He imported trees from Europe and instilled in his children and grandchildren a love of horticulture and an interest in agriculture and animal husbandry.

E. I. du Pont purchased the first acres of what would become Winterthur with gunpowder profits from the War of 1812. H. F. du Pont's father inherited the property in 1889. By then, Winterthur had sprawled to 1,135 acres. As children, H. F. du Pont and his older sister, Louise, had the run of the outdoors, with farm animals for companions: goats, sheep, poultry, and forty draft horses. In her late seventies, Louise recalled to Winterthur curator John Sweeney how her father drilled into them his interest in botany, and the process of learning through careful observation: "Father would take

Harry and me by the hand and walk through the gardens with us, and if we couldn't identify the flowers and plants by their botanical names, we were sent to bed without our suppers."

If their father, first in his class at West Point in 1861, was pompous and rigid, their mother, Pauline Foster, was warm and tender. Having lost five of seven children in infancy, she kept her son close and passed on to him her love of flowers that she shared with her mother-in-law, Louisa Gerhard du Pont, and other du Pont relatives. Pauline was the daughter of a gentleman farmer in New York, and she impressed upon her son that Winterthur was not a showplace but a country place, a retreat for repose. H. F. du Pont was shy as child and awkward around peers in his youth (he spoke only French when he first entered school), and he would credit his mother with his lifelong desire to reinforce the feeling of "great calm and peace" that Winterthur provided in his anxious childhood.

At age thirteen, H. F. du Pont was sent off to boarding school at Groton, Massachusetts. From letters to his parents, he hated being away and consoled himself with visual memories of home. He wrote of his joy at recognizing Winterthur's May-blooming Brandywine bluebells (more commonly known as Virginia bluebells, *Mertensia virginica*) in *Gray's Manual of Botany.* When he begged for permission to work in the nurseries of a garden center near the school, du Pont's parents fretted over their son of the manor getting his hands dirty and rubbing elbows with workingmen in Groton. But he had already performed chores for Winterthur's gardeners, who decades later would remark that du Pont could work as hard physically as any paid laborer.

Student at the Bussey Institution

After entering Harvard in 1899, du Pont reconnected with a childhood acquaintance, Marian Coffin, one of two women enrolled in the new landscape architecture program at the Massachusetts Institute of Technology. (Harvard did not admit women at the time.) Coffin's mother and du Pont's mother were close friends. It was Coffin who had urged du Pont to take courses at the Bussey Institution. Together, they studied in the Arboretum under John George Jack and toured Holm Lea, Sargent's 150-acre estate in Brookline, on the north side of Jamaica Pond. There, du Pont expected to find mature trees of enormous size but wrote home with disappointment that he saw only two, although he noted that "the Magnolias around the pond were in full bloom and magnificent."

Coffin found in Sargent a mentor who had already taken under his wing the early female pioneer in landscape architecture, Beatrix Jones (Farrand). Coffin's program at MIT, under the direction of Sargent's son-in-law Guy Lowell, emphasized geometric gardens in the neoclassical tradition. Homeschooled before college, Coffin found the heavy math requirement daunting. She credited Sargent with encouraging her to persevere, effectively saving her career at a critical moment of self-doubt.

The death of du Pont's mother in his junior year made him return home and spend his senior year helping his father run the household and its staff. After graduating, Coffin and du Pont would tour the great gardens of Europe together, with her mother as chaperone. In an era when few firms would hire a woman landscape designer or have one supervise all-male crews, Coffin struck out on her own. Du Pont, meanwhile, would become a valuable client and steer business her way. He put off planned studies in New York's Hudson Valley, at the School of Practical Agriculture and Horticulture in Briarcliff Manor, and began to apply at Winterthur the knowledge he had acquired at the Bussey Institution, experimenting with plants, observing how they performed, and carrying with him a notebook everywhere he went.

He started a trial of fifty-four different daffodils and planted the ones that performed best (*Narcissus horsfieldii, N. albicans,* and the cultivars 'Golden Spur', 'Grandee,' and 'Emperor') along the banks of a stream and on hillsides, in large drifts and massed colonies, never mixing them. A Bussey course on hardy herbaceous plant materials had introduced him to the ideas of William Robinson, the evangelist for naturalistic gardens, whose book *The Wild Garden,* published in 1870, had revolutionized landscape design in Britain. The Irish-born Robinson was an irreverent crusader against Victorian garden contrivances, from the bedding out of

COURTESY OF THE WINTERTHUR LIBRARY: WINTERTHUR ARCHIVES

H. F. du Pont relaxes in the Winterthur landscape, in 1904, with Marion Rawson and cousin Elaine Irving.

tender, tropical annuals in temperate climates to the idolatry of faux Italianate ruins. Instead, Robinson advocated for the use of winter-hardy plants and natural-looking gardens "devoid of any trace of man." Valencia Libby, who dug deeply into Winterthur's ties to the Arboretum, unearthed a paper that du Pont wrote at Harvard (about an aunt's estate, Virieux, which bordered Winterthur) that reveals Robinson's strong influence on an impressionable student. Robinson had also influenced Sargent and the Arboretum's original landscape architect, Frederick Law Olmsted.

Laconic rather than loquacious, du Pont never articulated his design principles in one comprehensive place for easy retrieval. Scholars have pieced them together from snippets he offered here and there and from the visual evidence he left behind. Above all, he strove to achieve the appearance of nature working effortlessly, with

the garden fitting into the landscape "as if it has always been there," he would say. He told visitors this design effect took a great deal of effort and was "very hard to do."

Estate Planner, Arboretum Benefactor

In 1909, when du Pont's father gave him control of the estate's grounds and greenhouses, the young horticulturist began acquiring plants with the zeal of an obsessive-compulsive collector on an unlimited budget, planting twenty-nine thousand bulbs that year and thirty-nine thousand the next. He carpeted the ground beneath tulip poplars (*Liriodendron tulipifera*) with snowdrops (*Galanthus*), winter aconite (*Eranthis hyemalis*), glory-of-the-snow (*Chionodoxa luciliae*), squill (*Scilla*), snowflake (*Leucojum vernum*), and crocus (*Crocus tomasinianus*). In the decades to follow, he would source bulbs, herbaceous perennials, and woody plants from the top breeders and more than fifty nurseries, chief among them the Arnold Arboretum.

Over the years, Sargent evolved from du Pont's professor and advisor into a peer and beneficiary. The du Ponts appear in Sargent's annual reports on the Arboretum to Harvard's treasurer beginning in 1915, when du Pont's father, Henry A. du Pont, made a donation to fund annual operating expenses, the equivalent of almost $2,500 today. Sargent, sensing an opportunity to cultivate new patrons to sustain the institution, pursued a personal relationship. He made personal visits to Winterthur, signing its guest book nine times between 1918 and 1923, usually during April, when spring in Wilmington is in full bloom while Boston is still dreary. Sargent already knew Wilmington as the home of the wealthy botanist William Canby, who collected forty-five thousand botanical specimens in his lifetime and had accompanied Sargent and John Muir on a tour of the Appalachians. Sargent grew close to H. A. du Pont, hosting him for personal tours of the Arboretum and the Hunnewell Estate, in Wellesley, where Horatio Hollis Hunnewell had popularized the cultivation of rhododendrons, especially the red torch azalea (*Rhododendron kaempferi*) that Sargent had brought over from Japan. Both Sargent and H. A. du Pont were veterans of the Civil War and patrician practitioners of *noblesse oblige.* In the twilight of his life, H. A. du Pont called Sargent his favorite friend.

In 1916, H. F. du Pont wed the more outgoing Ruth Wales, who had grown up in New York near his former schoolmate at Groton and Harvard, Franklin D. Roosevelt. The next year, Sargent wrote a letter inviting du Pont, the one-time Bussey student, forty years his junior, to serve on the Arboretum's governing committee, formally called the Harvard Board of Overseers' Committee to Visit the Arnold Arboretum. "The committee appointed by the Overseers has been of very great service to me now for many years in aiding [and] … in raising enough money … to keep the establishment going, the income from the endowment being inadequate for that purpose," Sargent wrote. "While the Committee has been of great service to the Arboretum in this way I have never gotten any horticultural or other advice from its members, and when I suggested to the overseers to appoint you as a member of the Committee it was with the idea that you should be able to help me horticulturally for in this direction I am left entirely without advice or assistance." Du Pont would serve the Arboretum in that capacity for fifty years, until 1968, the year before he died.

Over the years, du Pont would rely upon the Arboretum's experts for plant identification and sourcing, consulting its long-time propagator Jackson Dawson, Dawson's successor William Judd, and later director Karl Sax. With the Arboretum dependent on donors for fundraising, Sargent was more solicitous in correspondence than his staff, replying to one of du Pont's inquiries about the fragrant, white-blooming mock orange (*Philadelphus*) by writing, "If there is any particular kind you want, we shall be glad to have a plant propagated for you." Du Pont would return to the Arboretum again and again, always with a notebook in hand, on frequent visits to see his sister who lived with her husband, Frank Crowninshield, in Boston and Marblehead. After a visit in 1923, du Pont wrote Sargent: "The only trouble in going to the Arboretum is that I come back fired to possess all kinds of plants which, as you

know, are unprocurable elsewhere. After going through numberless catalogues I am absolutely stumped by the enclosed list, and I am wondering if little by little you could procure cuttings of these various shrubs, as I should so much like to have them."

During du Pont's first year on the Overseers' Committee, Henry Hunnewell, son of Horatio Hollis Hunnewell, initiated a capital campaign to grow the Arboretum's endowment. Du Pont and his father made gifts equivalent to six figures in today's dollars. Then, in 1918 and 1919, they each provided the Arboretum with its largest annual financial gifts from individuals. The Great War in Europe had been lucrative for the family's munitions business, and their wealth had multiplied thanks to three of du Pont's second cousins (Pierre S., Alfred I., and T. Coleman du Pont) who had taken control of the DuPont company and engineered its expansion into chemicals and a large stake in General Motors. H. F. du Pont would plow his share into developing Winterthur, collecting antiques, and creating a summer place for his wife in Southampton, New York.

Woodland Gardener

Before the Great War, du Pont and his father visited a conifer forest that was cultivated at the Dropmore estate, in Buckinghamshire, England. The estate dated to the eighteenth century, and some of its coniferous trees had been propagated by seed brought to England by early collectors. The sight of the rare specimens inspired du Pont's father to install a conifer collection at Winterthur. It grew to contain more than fifty different conifers recommended by Sargent and sourced by the Arboretum and thirteen commercial nurseries. Japanese umbrella pine (*Sciadopitys verticillata*), Japanese cedar (*Cryptomeria japonica*), and Atlas cedar (*Cedrus atlantica*) were among the selections. When laden with freshly fallen snow, Henry Algernon du Pont's dark-green Pinetum becomes Winterthur's own winter's door.

While H. A. du Pont installed the Pinetum, his son worked on what would become his crowning outdoor achievement: Azalea Woods. Beginning in early spring and continuing into early summer, eight acres of second-growth tulip poplar, white oaks (*Quercus alba*), American beech (*Fagus grandifolia*), and hickories (*Carya ovata*) are brightened, at eye level, with hues of white, pearl, blush, pink, and red. The design was not conceived at once in any grand plan but grew organically, like seeds sprouting in niches of opportunity opened by the demise of Winterthur's American chestnut (*Castanea dentata*), killed by blight.

Among the azaleas H. F. du Pont used were seventeen Kurume hybrid azaleas he purchased during a visit to Cottage Garden Company, on Long Island. The nurseryman Robert Brown had obtained them from Yokohoma Nursery Company, in Japan, which had won a gold medal for showing them at the San Francisco Exposition of 1915. (The Yokohoma nursery had also grown the bonsai collection that Larz Anderson acquired in 1913 and which his widow donated to the Arboretum in 1937.) At Winterthur, du Pont was delighted when the new azaleas bloomed a subtle shade of pink. From these original accessions, Winterthur propagated more until their progeny spread for acres. In 1920, when Sargent wrote to du Pont with excitement about a new azalea introduction that held great promise for the nursery trade (a group of Kurume azaleas that Ernest Henry Wilson had selected from Akashi Kojirō, a nurseryman in Kurume, Japan), du Pont modestly avoided telling Sargent that he had been working with Kurume hybrids for three years already. From the Arboretum came Hunnewell's *Rhododendron kaempferi,* and Sargent recommended royal azalea (*R. schlippenbachii*), praising it as "the loveliest of the hardy Asiatic Azaleas." In the 1930s, du Pont added broadleaved rhododendron hybrids from Charles Dexter of Sandwich, Massachusetts.

Today, Winterthur's plant database catalogues thousands of azaleas on the property, representing 252 species and varieties. The collection reaches peak bloom in Wilmington around the same time as Lilac Sunday at the Arboretum (Mother's Day, the second Sunday in May). In bloom, the shrub layer stands out against the tall trunks and their drab bark the way Boston's sleek John Hancock Tower, designed by I. M. Pei's partner Henry Cobb, plays off of the hefty brown masonry of Henry Hobson Richardson's Trinity Church. Without Trinity Church beside

Azalea Woods was one of the first landscapes that du Pont designed at Winterthur. It has proved an enduring masterpiece.

it, the modern glass tower could be an unmemorable building in almost any suburban office park. Likewise, without Winterthur's trees rising out of the shrub layer like giant columns, Azalea Woods would be just azaleas, an overscaled, formless mass of color, lacking apparent depth. At the herbaceous layer, du Pont again followed Robinson's ideas and planted great white trillium (*Trillium grandiflorum*), blue anemone (*Anemone apennina*), bluebells, bloodroot (*Sanguinaria canadensis*), lily of the valley (*Convallaria majalis*), smaller narcissi, and ferns to naturalize in colonies. While novice gardeners can be reluctant to uproot what they install, du Pont was a ruthless editor of his own work. He was a perfectionist about form and color and personally supervised the installation of trees and shrubs. In oral histories, his gardeners recalled how he would have them move a shrub mere inches to site it perfectly. He would have them plant and replant some shrubs five or six times until everything was right. Color dictated what went where. "For me, color is the thing that really counts more than any other," he told an interviewer at age eighty-two.

Viewed through a wide-angle lens, du Pont used color to emphasize the movement of bloom sequence, which rolls across the gardens at Winterthur like slow-moving, undulating waves. By grouping flowering shrubs, he strove for harmony of related hues, or complementary

colors at opposite ends of the color wheel. A signature color combination was mauve against chartreuse, which he produced by coupling two early blooming woody plants: the greenish-yellow blooms of winterhazel (*Corylopsis glabrescens*) with the Korean rosebay rhododendron (*Rhododendron mucronulatum*). He also brought outdoor colors inside the mansion, decorating rooms with fabrics and cut flowers to reflect what was visible through each window. Guests who arrived at Winterthur for the first time were bowled over by the volume of cut flowers in the public rooms. In the dining rooms, he matched table linens with the flowers and kept more than fifty patterns of china (not place settings but entire sets of china) to do the same with dinnerware. For decades, he kept meticulous notes on every table setting so that returning guests could be served on china they had not seen on previous visits.

Collector on a Grand Scale

The estate du Pont inherited in 1927, at age forty-six, spread to 2,600 acres. It contained ninety houses for the 250 or so employees working at the estate's mansion, gardens, and farms. The self-supporting community had its own railroad station, post office, a vast complex of twenty greenhouses and potting sheds, cold frames covering an acre, huge livestock barns, a sawmill, tannery, and dairy. Descended from wealthy gentlemen farmers on both

"I like to see the shape and size of big shrubs," du Pont would write. Here azalea masses drift beneath conifers at Winterthur Museum and Gardens.

sides of his family, du Pont had been managing all farm operations for thirteen years. On legal documents that asked for his occupation, he sometimes wrote "farmer." He even achieved fame for breeding a champion herd of milking Holstein Friesians, which won top awards from the dairy industry. He raised sheep and poultry, and his daughter remembered how he also loved his pigs.

Having full control to shape Winterthur to his liking, one of the first things du Pont altered was his father's Pinetum. To the son, it felt like a collection of specimens arranged artificially, so he naturalized it with quince (*Chaenomeles*) planted along its broad path, creating his Quince Walk. He gave shrubs room to grow to their natural form. In his single-paragraph foreword for Hal Bruce's 1968 book, *Winterthur in Bloom,* du Pont echoed Robinson and Sargent, writing, "I like to see the shape and size of big shrubs; even though they are always part of a group, one has to know when planting just how big and tall the shrubs are going to be." Against the dark greens of the conifers he also planted Winterthur's boldest flame azaleas (*Rhododendron calendulaceum*), which bloom in tangerine, apricot, salmon, and lemon yellow. Later, he added a dawn redwood (*Metasequoia glyptostroboides*) from the Arboretum.

Du Pont then enlarged the big house, which grew to 175 rooms, to accommodate his expanding collection of American antiques. According to his daughter, du Pont's interest in early Americana was sparked by a visit to the Webb estate, in Shelburne, Vermont, in 1923, when he spotted pink Staffordshire china arrayed on a brown pine dresser. Those very pieces are now displayed among the ninety thousand objects of decorative art in Winterthur's collection. A visit that same year to the Gloucester, Massachusetts, home of Henry Davis Sleeper (now owned by Historic New England) inspired du Pont to install period rooms lifted from colonial era houses, as Sleeper had done, and as Ben Perley Poore had done in a haphazard way before at his estate, Indian Hill, in nearby Newburyport.

Du Pont's genius as a designer of naturalistic landscapes shows in the way he fit his mansion into the existing topography. He left the north elevation of the existing house at four stories, but on the opposite side, he tucked nine new stories into a steeply sloping hillside that absorbed the height and volume. He also sited the building and new entrances carefully within an envelope of mature oaks, beech, and poplars. The height of the trees, at 150 feet, made the mansion appear less large. From Robinson and Olmsted, he had learned to subordinate built structures to their natural surroundings.

As he expanded the house, du Pont hired his friend Marian Coffin to makeover the gardens along its southern shaded slope, which cradles a swimming pool and twin pool houses. The gardens Coffin designed were the most formal at Winterthur, arranged on straight axes punctuated at the ends by semicircles. Her talents complemented his. She architected the skeleton, and he fleshed it out. He outfitted the design with plants, softening her stonework and straight lines with shrubs and understory trees that he allowed to grow naturally, out over the edges. As collaborators, Coffin and du Pont would bounce ideas off one another throughout their lives. Du Pont wrote her playfully during their work on the project, "I am enclosing a copy of a letter from Mr. E. H. Wilson of the Arnold Arboretum in regard to the *Picea asperata notabilis.* This is the tree which you wished so ruthlessly to destroy." Native to Sichuan, China, dragon spruce (*Picea asperata* var. *notabilis*) was described by Wilson and Arboretum taxonomist Alfred Rehder, in 1916, and is considered endangered today.

Du Pont weaved Coffin's formal gardens into Winterthur's naturalistic grounds by dissolving boundaries within the landscape. Like Olmsted's design of the Arboretum, there are no obvious seams between garden areas at Winterthur, only gentle transitions. The edge of Azalea Woods dissolves into the meadow beyond it, with shrubs extending out from under trees like an irregular line of troops beginning their advance on an open field. Following Robinson's dictate, Winterthur allows the lower limbs of trees to grow into the ground naturally, eschewing cuts in turf for neatly delineated beds where field and forest meet. Whereas du Pont's cousin Pierre, at Longwood Gardens, had used princess trees (*Paulownia tomentosa*) to line a formal allée to the entrance of his monumental conser-

vatories, H.F. du Pont inserted *Paulownia* into his woodland edge as a transition element, its lavender blossoms catching the eye and leading visitors to the next sequence of seasonal bloom. A large mound of saucer magnolia (*Magnolia* × *soulangeana*), planted by du Pont's father in 1880, the year du Pont was born, carries the spring bloom into fields of grass, as do two large Sargent cherries (*Prunus sargentii*) beyond them, gifts to Winterthur from Sargent in 1918. Nearby, du Pont collaborated with Coffin again to create an April-blooming garden of fragrant ornamental trees and shrubs, many of which came from the Arboretum through its Cooperative Nurserymen program.

Planner for Posterity

In 1930, as du Pont's sister, Louise, planned for the future of Eleutherian Mills, the family's restored ancestral home, H.F. du Pont established a nonprofit entity charged with maintaining Winterthur in perpetuity as "a museum and arboretum for the education and enjoyment of the public." The museum opened to the public in 1951, when du Pont relinquished responsibility for it to professional staff. He continued to oversee the gardens and farmland, calling himself head gardener.

As he grew older, du Pont became more impish in the garden. He relaxed his highbrow standards of what constituted good taste. Before mod fashion in the 1960s made pink and orange a popular color combination, he inserted salmon blooming azaleas as accents into his Azalea Woods and placed bold, red-blooming azaleas next to lavender ones to "chic it up," in his words. Coffin praised what she called his "near discords" of color. Tossing aside rules he learned about cool, pastel subtlety from the teachings of Gertrude Jekyll, he installed a

In 1929, du Pont commissioned his friend Marian Coffin to redesign the south-facing slope below his mansion. Du Pont softened the formal lines with masses of shrubs.

carnival of hot colors in his summer Quarry Garden using primroses (*Primula*). Gordon Tyrell, who worked closely with du Pont in the garden, confided in a colleague, "He was mixing colors. I know he did it intentionally, but they were beginning to yell. There were lavenders and mauves and reds. It wasn't offensive, but I think it was a little joke of his really. And I said, 'You can't do this.' And he said, 'I'm doing it.' And he did it."

Although du Pont loosened Jekyll's tether on color, the aging gardener remained devoted to William Robinson's naturalistic aesthetic into the ninth and final decade of his life. When he hired architects to design a pavilion that became Winterthur's visitor center, he told them, "Make it look like it isn't there." Tucked within his woodland, the modernist building is the color of bark, and its glass exterior walls reflect the foliage around it, camouflaging its mass. The approach road to the visitor center follows swales around hills, through open meadows. He had the road sunken below sightlines so as not to mar the views.

Coffin liked to tell prospective clients that great gardens require three things: money, manure, and maintenance. Winterthur had all three in abundance. After du Pont's death in 1969, his endowment supplied the money, but the manure had to come from elsewhere. His will stipulated that his livestock operations be liquidated upon his death, to focus resources on the museum. Because du Pont oversaw and financed the gardens until he died, it took the institution two decades to formalize a Garden Department to preserve his landscape design intent. By then, his naturalistic garden was overgrown. Three years were spent assessing what was there and culling what shouldn't be, including forty truckloads of branches pruned from Azalea Woods. In the Pinetum, a mature Atlas cedar (*Cedrus atlantica* 'Glauca') was pruned at its base to reopen the circular seating area and sightlines around it. The spot reminds a visitor of the vantage point atop the Arboretum's Bussey Hill Overlook, where puddingstone boulders in the ground encircle the base of a large eastern white pine (*Pinus strobus*) and Japanese white pines (*Pinus parviflora*). At Winterthur, Sargent's role in shaping the Pinetum is memorialized on a plaque.

Decades before, when du Pont planted bulbs by the tens of thousands, he wrote to Coffin that no mere mortal could do what he wanted done at Winterthur. And he was right. What makes Winterthur unique in America is its scale—the product of vast wealth, space, and time. Few landscapes in the new world are the work of generations of a single family, let alone one man's lifetime of eighty-nine years. Today, Winterthur fulfills Henry Francis du Pont's wish "that the museum will be a continuing source of inspiration and education for all time, and that the gardens and grounds will of themselves be a country place museum where visitors may enjoy as I have, not only the flowers, trees and shrubs, but also the sunlit meadows, shady wood paths, and the peace and great calm of a country place which has been loved and taken care of for three generations."

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Carter Wilkie grew up near Winterthur, where his mother took him on frequent visits and would quiz him to identify plants she had pointed out on previous walks. For thirty years, he has resided within a short walk of the Arboretum, where he can be spotted reading tags on trees. This article is based on a talk he gave to the local garden club in Roslindale in March 2018.

Eternal Forests: The Veneration of Old Trees in Japan

Glenn Moore and Cassandra Atherton

The accounts of foreign visitors who began arriving in Japan after the Meiji Revolution, in 1868, show that the newcomers were intrigued by the Japanese relationship with trees. Sacred trees were noted as important features around shrines. Old trees were marveled over, especially given the affectionate care the trees received, as were the miniature bonsai that could be hundreds of years old and require daily tending. But the visitors focused especially on the cherry trees (*Prunus serrulata*) and their brief but spectacular show of blossoms. Writer Lafcadio Hearn was no exception, and he recorded fables like "The Cherry Tree of the Sixteenth Day" in his classic book *Kwaidan,* published in 1904.[1] Tourists today have the same focus, resulting in the peak season for tourism to Japan happening in early April, when the cherry trees are in bloom. Massed blossoms are the perfect photo opportunity—they accounted for a massive twenty-nine million Instagram posts in 2018—and the cherry-blossom-viewing ritual, known as *hanami,* is an attraction in itself. The ritual involves siting on blue tarpaulins beneath the trees and drinking sake while the fragile blossoms fall. This is promoted to tourists as indicative of a society whose people accept "the fleeting nature of life."[2]

Although the symbolism of the cherry blossom certainly seems to fit with a nation

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that has endured earthquakes, tsunamis, and typhoons, *hanami* is just a small part of how trees fit into traditional Japanese culture. This relationship is rooted in Japanese history, folklore, and religion. Trees and nature are central to Shinto, a religion that originated in Japan, which holds that spirits inhabit trees that reach one hundred years of age. These tree spirits are known as *kodama,* and according to Japanese folklore, the *kodama* give the tree a personality.[3] Accordingly, in premodern Japan, old trees were regarded with awe and a degree of caution. In fact, they were marked with a sacred rope called a *shimenawa,* warning that if anyone chopped down the tree, they would have to deal with an angry spirit.

Although it seems unlikely that these folkloric beliefs could survive in modern, urbanized Japan, they proved surprisingly adaptable. The idea of tree spirits was kept alive in storybooks and anime (most notably the Hayao Miyazaki film *Princess Mononoke*), and belief in the presence of *kodama* in old trees continues. So, while it might be more accurate to say that many of today's Tokyoites are likely to think in terms of old trees having admirable *qualities* rather than *personalities,* they nevertheless respect the trees for their age and resilience, and can be seen paying homage to them at shrines and in parks, or simply spending time in their presence as an antidote to the stress of modern life.

Eternal Forest in Tokyo

Tokyo is a modern city, and to a visitor, its residents seem totally immersed in their busy, modern lives. Salarymen dressed in suits and ties rush from train stations to their offices; young people sit in coffee shops engrossed in their phones; and people shop in gleaming department stores. It is easy to lose sight of the fact that Japanese traditions and myths persist behind what writer and cultural historian Boyé De Mente refers to as a "Western façade."[4] While not everyone today believes in the ancient myths in a literal sense, Shinto master Motohisa Yamakage has described how myths and related Shinto beliefs are still woven into the fabric of everyday Japanese life.[5] For example, construction crews typically wait for a Shinto priest to purify a new worksite; major league baseball teams like the Hiroshima Carp receive a Shinto blessing before spring training; and almost everyone visits one of Japan's eighty thousand Shinto shrines on ceremonial occasions. It is during these shrine visits that the role played by trees in connecting people with the nation's mythic past becomes apparent.

Meiji Jingū, a shrine in Tokyo, is not old by Japanese standards. It was completed in 1920 to honor Emperor Meiji and Empress Shōken. All Shinto shrines are surrounded by trees, which are thought to provide a conduit to the gods. While these shrine forests, or *chinju no mori,* are ideally "old primeval forests," providing a living link to "the ancient age of myths,"[6] everything at Meiji Jingū had to be planted from scratch, which required a staggering one hundred thousand trees. The long-term goal was to create an "eternal forest" dominated by long-lived trees like zelkova (*Zelkova serrata*) and ginkgo (*Ginkgo biloba*), but because of the more immediate need to have a forest with an atmosphere appropriate for a shrine, a 150-year program was devised, whereby fast-growing trees—most notably Hinoki cypress (*Chamaecyparis obtusa*), Japanese cryptomeria (*Cryptomeria japonica*), and two species of pine (*Pinus densiflora* and *P. thunbergii*)—provided at least the appearance of a *chinju no mori* before the slower-growing, broadleaf species gradually took over.[7]

Even with fifty of the 150-year program remaining, the Meiji Jingū forest has begun to feel old. It attracts ten million visitors every year, with three million coming in the three days after the New Year to pray. Wishes for the coming year are written on wooden tablets called *ema,* and these are left at the foot of a camphor tree (*Cinnamomum camphora*), which is believed to transmit the wishes to the deified emperor and empress. Visitors repay the trees with affection and respect, and the shrine's tree-viewing etiquette is rigidly adhered to. As soon as visitors pass through the ceremonial wooden *torii* (gate) they are in sacred space, and a quiet, respectful demeanor is assumed. No one leaves the paths to walk on the forest floor; no one picks leaves or seeds from a tree; and no

Facing page: **Branches of old Japanese red pines (*Pinus densiflora*) are supported with props in a Kyoto park.**

PHOTO BY STEPHEN SCHNEIDER

STEPHEN SCHNEIDER

A ceremonial *torii* leads into the Meiji Jingū forest.

one removes anything from the forest—even fallen leaves are left on the ground.

Fabled Trees of Tokyo

The desire to connect with Japan's spiritual and mythic past is accompanied by a strong feeling of connectedness with the nation's history. As a result, a number of Tokyo parks and gardens with old trees that have witnessed the city's history unfold have been given status as national monuments and historical landmarks. One of the most popular of Tokyo's historic landmark parks is the Institute for Nature Study, a 49-acre (20-hectare) forest that doubles as a research facility and a green oasis for the people of Tokyo. The Institute for Nature Study was once the feudal estate of the Matsudaira, a samurai clan related to the shogun (the military ruler of Japan). The star attraction is the Fabled Pine, an enormous Japanese black pine (*Pinus thunbergii*) that was part of the Matsudaira garden in the early 1600s. People typically bow before the old tree, which provides a living link to this emblematic era of Japanese culture—a symbol of cultural continuity.

The Fabled Pine also offers a reassuring example of resilience. The old tree's never-say-die spirit was underscored when the second-oldest tree in the Institute for Nature Study forest, a Japanese black pine known as the Ancient Pine, was toppled by a typhoon in October 2019. The fact that the Fabled Pine survived when even its venerable neighbor succumbed has only added to its mystique. Indeed, many of the visitors who stream up to the tree every day would be aware that the tree had survived a long list of disasters that began with the Great Fire of Meireki, in 1657. That fire burned 70 percent of the city and took over one hundred thousand lives—far more destructive and deadly than the Great Fire of London, nine years later. Earthquakes were also a constant threat. Major quakes hit the city

GLENN MOORE

A prominent zelkova (*Zelkova serrata*) at Shinjuku Gyoen is more than four hundred years old.

in 1703, 1855, and 1894; then in 1923, the biggest of them all, the Great Kantō Earthquake, flattened most of the city. During World War II, Tokyo was spared the horror of the atomic bomb, but the city's trees were decimated by the relentless American firebombing.[8]

The chances of any tree surviving this litany of disasters is illustrated by the fact that of the twenty thousand trees in Shinjuku Gyoen, one of Tokyo's largest parks, only two, a 150-year-old magnolia (*Magnolia denudata*) and a 400-year-old zelkova (*Zelkova serrata*), are over one hundred years old. The zelkova—the star attraction—is showing signs of age. Its trunk was severed about ten feet from the ground, and new branches poke through a protective coat that was wrapped around the trunk to nurse the tree back to health. On face value, a tree that needs to be nursed back to health is an unlikely symbol of resilience, but as J. W. T. Mason has explained, according to Japanese tradition, great age and "special hardihood" are evidence of a tree's "vital powers."[9] The broken trunk and protective coat emphasize the battles the tree has fought, and give heart to residents of Tokyo that they can cope with the stresses and strains of their daily commute, long working hours, or, if they are young, looming exams.

Survivor Trees of Hiroshima

Never was Japanese resilience tested more than in the aftermath of the atomic bomb dropped on Hiroshima, in 1945. The bomb blast and resulting fires killed 140,000 people and destroyed all but a few buildings within an approximately 1.2-mile (2-kilometer) radius of the hypocenter. Survivors then began experiencing radiation sickness, resulting in death from cancer. At first it seemed as though the city's trees were following a similar trajectory. Most were instantly torn out of the ground or had their trunks snapped in half. The few trees left

standing were seared by a blast of heat so intense that a streetcar over a half mile (900 meters) from the hypocenter was completely oxidized. As one city administrator put it, the bomb had reduced the city to "an ashen coloured wasteland bereft of all green."[10] The fear was that nothing would grow in the radiation-affected soil for seventy-five years.

Not surprisingly, residents were resigned to abandoning the city, when, almost miraculously, green shoots began emerging from some of the blackened, charred branches. A few trees, so burned and broken that they had no viable branches left, somehow managed to sprout new shoots out of their blackened stumps. A weeping willow (*Salix babylonica*), merely 0.2 miles (370 meters) from the hypocenter, was completely felled by the blast but managed to send up new shoots directly from its roots.

In all, 170 trees regrew after the blast. *Hibakusha* (people who survived the bomb) have given testimony that the resilience shown by the *hibaku jumoku* (survivor trees) helped convince them that life could return to the city. Akio Nishikori was a second grader when the bomb fell. "We were told nothing would grow for seventy-five years," he recalled. "However, trees put out new shoots! Everyone was really moved to see the green leaves. These trees were the first to encourage humans [to rebuild.]"[11]

In 1946, governor Kusunose Tsunei enlisted six community representatives to help him formulate a plan for restoring the city. As a city administrator explained, the consensus was not to "create everything anew." Rather, the aim was to restore the "social functions, culture, and traditions that had existed in the Hiroshima communities before the bombing."[12] This meant many things. Hiroshima Castle, flattened by the bomb, was rebuilt. Hondōri, the city's ornate shopping arcade, was restored to its former glory. But most importantly, Kusunose's panel was adamant that "many trees should be replanted in the city."[13] It was no small task to grow trees in soil that had been burned by a nuclear blast and that was laced with rubble and debris, but today Hiroshima is a green city. Trees growing in parks and along rivers and roads give Hiroshima the look and feel it had before the war.

The survivor trees provided living links to that prewar period, and the city was effectively rebuilt around them. Commemorative plaques were installed, and the trees have been preserved and tended into old age, even in cases when it might have been more convenient to remove them. A fine example of this respect is an old ginkgo (*Ginkgo biloba*) that, before the bomb was dropped, stood on the grounds of the Hosenbo Temple. The temple was levelled by the blast, and the head priest and his family were killed. The ginkgo had branches torn off and was badly burned, but it survived. When rebuilding began in 1994, the priests realized that the ginkgo, now a very large tree, would have to be removed to accommodate the architectural plans. Not willing to cut down a tree that had displayed such courage, they asked the architect to alter the plans, so that the temple could be built around it, preserving the tree as a symbol of resilience and continuity.

Walking among Old Trees

In 1982, Tomohide Akiyama, director of the Japanese Ministry of Forestry and Fisheries, coined a new term: *shinrin-yoku* (forest bathing.)[14] In fact, although it was a new word, the idea was connected to the very old Japanese notion that being among trees was good for health. In time the idea would become mainstream, with books written about how to get the most out of forest bathing and with one thousand government-accredited Official Recreation Forests now including *shinrin-yoku* trails. But when Akiyama coined the term, in 1982, he was also responding to a growing unease about the shift from agrarian to urban lifestyles, and the stress of modern life. By the 1980s, 80 percent of the Japanese population was concentrated in cities, seemingly far removed from nature. Long commutes, even longer workdays, and the constant pressure of not making a mistake would lead to Japan becoming recognized as the most sleep-deprived country on earth. There is even a Japanese word—*karoshi*—for the concept of death by overwork.[15]

Initially, there was no scientific basis for Akiyama's assertion that "being in the forest makes our bodies healthy," but there was a sense that the idea was at least plausible.[16] Chiba

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A weeping willow (*Salix babylonica,* left) was among the 170 trees that survived the atomic bombing of Hiroshima, as was a ginkgo (*Ginkgo biloba*) at the Hosenbo Temple.

University horticulture professor Yoshifumi Miyazaki, who would later conduct studies on the value of *shinrin-yoku,* described this prevailing sentiment: "The practice of walking slowly through the woods, in no hurry," made "intuitive" sense to the Japanese.[17] This intuition was partly rooted in knowing how much better it was to smell pine trees instead of car fumes, or to hear birds instead of harsh city noises, but at a spiritual level, it was also connected to the deep traditions associated with trees. As Shinto Studies professor Sadasumi Motegi put it, shrine forests and parks with old trees "are places that remind one of distant, ancient times. This is where the voices of the gods (*kamigami*) sound in your ears. This is where our ancestors lived, humbly, in harmony with nature."[18]

In 1990, in a study funded by the Japanese national broadcaster NHK, Miyazaki set out to test whether the spiritual benefits of reconnecting with nature were matched by medical benefits. To that end, he monitored the effects of walking through a forest on stress hormone levels in the human body. The findings were promising but inconclusive. Subsequently, he received a large government-funded grant allowing him to conduct more detailed studies. These studies have shown that there are not only emotional benefits from spending time in a forest but also measurable physiological benefits. For instance, office workers with stress-related high blood pressure had their levels lowered after spending six hours in an old growth forest. But the truly remarkable thing was that those with low blood pressure had their levels raised.[19] In effect, forest bathing, or *shinrin-yoku,* restores the balance that is so hard to achieve in modern life.

While science has supported the effectiveness of *shinrin-yoku,* the spiritual element involved has made it harder to explain in scientific terms how it works. As Miyazaki conceded in 2018, "we need to do more research." What is known, however, is that it works best in an unspoiled forest setting, pristine enough for moss to grow freely, and where old trees live. Moreover, *shinrin-yoku* requires intentionality to work

GLENN MOORE

***Shinrin-yoku* paths wind through the landscape at the Institute of Nature Study in Tokyo.**

correctly. As Qing Li, the chairman of the Japanese Society of Forest Medicine, cautioned, "This is not exercise or hiking, or jogging. It is simply being in nature, connecting with it through our sense of sight, hearing taste, smell and touch."[20] In other words, forest bathers should proceed at the same sedate pace and with the same quiet, respectful attitude as when they visit a shrine forest.

Bridging Past and Present

Japanese city parks all at least aspire to a natural, unspoiled look, and many contain astoundingly old trees. This design intention is evident, even to a traveler, looking for cherry blossoms. Flower beds, a staple of parks in Western cities, are rare, and any lawns come with rules prohibiting ball games, music, or other activities that would shatter the serenity. Jogging is rarely permitted. When the Fabled Pine at the Institute for Nature Study, in Tokyo, was first planted under the auspices of the Matsudaira clan, more than four hundred years ago, the residents of the estate could never have imagined modern cities like Tokyo or Hiroshima. However, one thing they would find comfortingly familiar is the sustained relationship with trees. Shrine trees are still sacred. And old trees are still revered for their resilience, and they still provide a bridge back to the past—indeed, even to the Matsudaira clan itself.

As visitors at the Institute for Nature Study walk along the narrow path that wends through the trees, around ponds and over creeks, the city

seems a million miles away. It was as if the park was designed specifically with *shinrin-yoku* in mind. The older trees are not, as in many parks, "features," standing unnaturally apart from the rest of the plants. Instead they rise through a bed of saplings and bushes. Moss covers everything, underscoring the sense that the trees are growing in a pure, natural environment. Although Tokyo has changed so much over the last four hundred years, the Matsudaira clan would surely recognize the thinking behind *shinrin-yoku*, namely that spending time with trees is a life-giving activity.

Endnotes

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[17] Miyazaki, 9.

[18] Rots, 85.

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Colony of Wild Leeks

Each Year in the Forest: Spring

Andrew L. Hipp
Illustrated by Rachel D. Davis

I spend the last weeks of each February brushing leaves aside, anticipating spring shoots. The first I find is often false mermaid, born beneath the maple litter. Its three-lobed leaves fold over themselves like the fingers of a glove. The fleshy cotyledons, newly hatched from the seed, are embedded a millimeter or two below the surface of the soil, soft and green on their inner surfaces, roughened on the backs where the clay and sand cling. The roots are spidery and translucent, barely a fifth of the height of the plant. The long petiole is ghostly white at the base and striated with elongating cells. It gradually darkens to a pale green just below the leaf blade, while the rest of the plant unrolls at the base.

Once the false mermaid is out, I know all hell is about to break loose in the understory. Soon wild leeks prickle from the soil's surface, pale at the tips with crimson sheaths. Cut-leaved toothwort arches as it extracts its inflorescence from the soil. Its leaves are feathery and purple. Spring beauty reclines beneath the duff accumulated at the bases of the tree trunks or matted on the forest floor, fragile white stems spreading into green, strap-like, delicious leaves that

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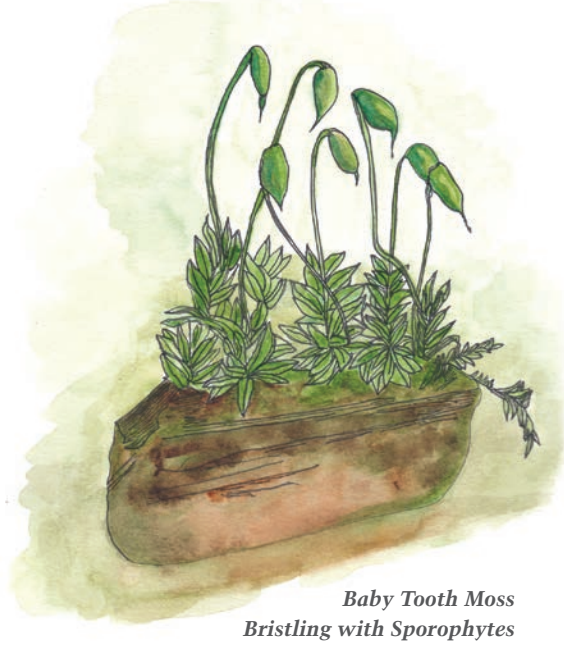
have not yet become bitter. Some of the spring beauty grow so far in search of light that their stems become threadlike. Bullet-shaped mayapple shoot-tips cluster at the bases of the oaks, each tip a half-inch high, clothed in white scales, like a goblin's fingertips. Wood violet rhizomes squeeze out infinitesimal soft green leaves. Rain buries the rhizomes in floods of soil and washes them downslope. Still they continue to grow.

Mosses green up on decomposing logs and on soil that was sterilized by the burning of cut buckthorn in previous years. The mosses form a bed for flowering plant seedlings and a barrier between spongy, rotting wood and the desiccating air.* Mats of wavy starburst moss bristle with sporophytes, capsules at the tips of the filaments popping open to release a little dust storm of spores when I brush them. The spores float off and settle onto nearby plants and logs. Sporophytes wearing slender hoods emerge from a tussock of baby tooth moss, resembling bristles on a hairbrush. The leaves are as thin as the pages of a Bible, with the smallest possible teeth on the margins. Over the next few days, the capsules begin to swell and bend, and soon they are nearly perpendicular to the sporophyte stalks. The hoods split along the side. Within two or three weeks, they will be fully reflexed. They produce spores before most flowering plants in the woods start exchanging pollen.

Evergreen leaves that have been working all through the winter give way. White bear sedge sends up blue-green shoots from broad-leaved, leathery rosettes. Pennsylvania sedge produces slender tillers, and even the leaves that overwintered brighten up. Winter leaves of white avens and strawberry and hepatica continue photosynthesizing as they pass the baton to the young leaves, which emerge as wrinkled as newborns, readying themselves to become next year's evergreen foliage.

False Mermaid



Baby Tooth Moss Bristling with Sporophytes

White Bear Sedge *Pennsylvania Sedge*

Infant soil centipedes curl on red oak chips that are decomposing in beds of earthworm castings. Chorus frogs sing and then retreat as the temperature swings. Spring peepers awaken and accompany me on my morning walks with strident, individual squeaks. I follow them into a weedy marsh, and suddenly I am in a fog of peepers blasting away, chorus frogs creaking behind them, but not a one to be seen. As I walk away, their calls attenuate, and in two hundred feet I no longer hear them. It is this way with peepers: a person could go through an entire spring within a quarter mile of a pond of peepers awakening and wooing in springtime and never know they were there.

II

That was the first week of March. Soon, wild garlic sprouts from gravelly roadsides and trail edges, slender as grass. Scales loosen on the flower buds of silver maples growing along city streets and creeks. The scale margins whiten with hairs, then the buds open and spill out a handful of stamens or dark-red, tentacular paired styles. Hazelnut catkins descend and are at first stiff, then looser a few days later, bracts cupped like umbrellas over the anthers balled up inside. Then they relax just a bit more and the anthers open. I cannot resist tapping the catkins growing together on a shrub, making them wobble like rows of prayer wheels and release clouds of pollen.

Male woodcocks skate through early March mornings, peenting in openings in the grasslands before soaring overhead, making a distinctive kissing sound

when they reach the top of their aerial dance. On my bike ride into work at the Morton Arboretum, in the western suburbs of Chicago, I often hear the woodcocks spinning over the arboretum's easternmost marshes and fields as I unlock the gate. It is still dark out, and they are flying high overhead before they drop onto gravel roads, openings in the marshes, or mown fields around the cultivated collections. When I hear one calling from the ground, I will sometimes wait for the flight upward, then race to where he was. Almost invariably he drops down too far away, and I don't find him. Once last spring I succeeded in seeing one drop back and resume his dance. He barely lifted his chin when he called. After each "peent," he paused and did a head-nodding shuffle forward and then backward before calling again. He seemed to wait for a response each time, shuffling as though in anticipation of the next call, a restless suitor. He called about five times before growing silent and then abruptly flying off to circle overhead.

We'll have a few weeks of dancing woodcocks before they grow quiet and a portion of the flock moves farther north. We'll see them again on their way back through in the fall. Flocks of juncos buzz and pop in the shrubs, tails flashing as they whip back and forth over the trail. Last year's stump puffballs show up crushed against logs, and expired earthstar fungi nest in the wood chips. White ice fills ephemeral pools like congealed clouds on days when the temperatures rise to 50°F (10°C). The ice then melts outward from the maples and elms that perforate the pools, until the water is wide open, with only a glaze of clear ice returning on late-March mornings when temperatures dip below freezing. False mermaid, now a few inches tall, bunches up in openings in the oak leaves.

Bluebirds perch on the lateral branches of bur oaks and scan the thawing turf for insects. Eastern phoebes return. One day, near the end of the month, I hear the protracted bubbling song of the winter wren. It stops for a few seconds, then starts again, five seconds of a complex line. The song twists around tree trunks and lichen-covered branches that were knocked to the ground by winter storms. I follow it and, if I am lucky, find the wren picking its way among mosses and scraps of soft wood, from one end of a rotten log to the other. A flock of American robins spreads out across the forest floor, solitary birds flipping leaves over one by one, looking for millipedes and pillbugs. It will be completely silent except for an occasional chuckle from the robins and the sound of leaves rustling, which might be the wind's doing if it were not the robins'.

III

Early April stammers as temperatures drop. This is the lull before the pandemonium of spring wildflowers. False mermaid is widespread, but not thick anywhere. It bolts, overtops the mottled sheets of oak and sugar maple leaves, and spreads across the bare soil of ephemeral watercourses. A week later, it carpets the woods. Spring beauty sprawls beneath the oaks, flower petals streaked with pink. Bloodroot flowers emerge, stalks wrapped in the solitary leaf. Rain a few

days later knocks their petals to the ground. Jewelweed cotyledons pop out on bare upland soil and floodplains, each the size of a nickel, fleshy and bitter. The lavender flowers of hepatica arise beside its light-green, rubbery new leaves, often at the bases of oaks where the plants are protected and where they can soak up rain that flows down furrows of the bark. The white flowers of false rue anemone pool in colonies scattered throughout the woods.

One morning, on my bike ride into work, I find the field sparrows have started claiming territory. Their bouncing song rings through the woods for a minute before I reach a field embedded in the woods. Chipping sparrows trill and harvest insects from the swelling oak buds. Tree swallows patrol the birdhouses. Ruby-crowned kinglets flit in the lower areas of the woods, moving continuously, singing an uncontainable song that breaks open and spills through the leaves around me. Chorus frogs and spring peepers are exuberant and everywhere. I park my bike and walk in, and when I pause to list the birds I've been hearing, the first tick of the season crawls across my notebook. Mourning cloak butterflies come out from beneath panels of tree bark where they have slept out the winter. Bumblebees and painted ladies cross the trail.

Then a late-season snowfall buries the wildflowers. Mayapples huddle in bunches against the snow, like passengers waiting for the bus in a blizzard,

False Rue Anemone

Jack-in-the-Pulpit

leaves tucked tightly under their chins. Spring beauty in full flower reclines against a log where it is protected from the drifts. Wild leeks and Virginia bluebells are rigid, frozen in mid-expansion, figures in a wax museum. Then the next morning it is 60°F (15°C), and the snow melts away.

By mid to late April, Dutchman's breeches forms puddles of foliage on slopes and disturbed trail margins. Its flowers school above the leaves. When the plants first emerged in early March, I hardly noticed them, flower buds condensed like frog eggs on the translucent scapes. Now, the white flowers mature from bottom to top, petals stretched back into deep spurs, stigmas arched at the snout. Jack-in-the-pulpit spears upward through the foliage before it grows tall enough to spread its wings. Soon it sends up a slender, fleshy inflorescence axis packed densely with pistillate or staminate flowers that I only see by carefully peeling back the hood. Wild ginger leaves appear at the tips of the rhizomes, folded over one another as they emerge, light green and hairy among trampled dead maple leaves. They spread open as soon as their blades are free of the earth, then lie back to sop up the sun. Jewelweed cotyledons I noticed in early March give way to scallop-margined foliage. And leaves begin to come out on the trees, unfurling like wet handkerchiefs on sugar maple seedlings and dripping from the tips of the hackberry branches.

False mermaid has grown lanky. One day I notice its three diminutive petals, about two-thirds as long as the green sepals that alternate between them. They form a crown around three or six stamens, tipped with yellow anthers, and two or three prickly ovaries. The flowers, like the plants themselves, are easy to miss if you are not watching closely, and I sometimes miss their opening. If I have been particularly inattentive, the ovaries may already be swelling by the time I first see the flowers. The first plant I watched for in February does not flower until the spring ephemerals—toothwort, spring beauty, Virginia bluebells—are already in full bloom.

IV

Yellow-rumped warblers appear near the middle or end of April with little warning. I typically hear them before I see them, singing from high in the canopy, and I struggle to remember whose song it is until I see the warblers stalking among the branches or catching flies midair. I will perhaps have already noticed blue-gray gnatcatchers bizzing and wheezing along the tree branches. Soon after, black-throated green warblers show up in the neighborhood, singing in the highest tree branches on our street as they warm up in the mornings. I know we are in the thick of warbler migration when I hear the lazy "bee-buzz" of the blue-winged warblers coming from trees along the edges of fields. Ovenbirds call insistently from the shrubbiest areas of the woods. Black-and-white warblers squeak in the midstory like rusted bearings. Last year, one struck an herbarium window at the arboretum and lay stunned. His eyes closed slowly, and he rolled onto his side on the window ledge. I reached out to retrieve him, but he flipped over and flew off between the branches of the European beech that shades the window.

At about the time that the yellow warblers and common yellowthroats start singing, wood thrushes return to a stand of closely planted spruces embedded in the arboretum's East Woods. The stand is low, with intermittently running water and a thick undergrowth of wood nettles that by this time is tall enough to sting my knees. This habitat seems to be just right for the wood thrushes. In the afternoons, orioles will be tearing at catkins in the tops of the red oaks and piping their hearts out. One evening, American toads begin droning from the marshes. Their song spills out into the adjacent forest. There are a few more weeks left in spring, but we are at the turning point to summer.

Wildflowers flood the woods, running in sheets across the fallen oak leaves and overtopping the spring foliage that has carpeted the woods in the past two weeks. Spring ephemerals have peaked and begun to fruit, as they race to complete their entire annual life cycle on the sunny forest floor before the leaves are fully out on the trees. Cut-leaved toothwort, which flowers with petals the size of a child's incisors, produces siliques, slender capsules that crack open along the sides to release an abundance of small seeds. The flowers on Dutchman's breeches ripen to capsules. Rivers of Virginia bluebells flower, then the corollas fall off, leaving the capillary style ringed at its base with swelling hard nutlets.

The first flowers of wild ginger open beneath the foliage, a pelage of long hairs combed over the backsides of the calyx, purple sepals tipping backwards. Anthers dangle from tiny flowers on male plants of early meadow-rue, and the females' flowers are frosted with stigmas. Rue anemone forms beds of beautiful, full-faced white blooms, some doubled so you might take them for cultivars. Glaucous branches of blue cohosh twist like dancers. Capsules swell thick as bullets on bloodroot.

As the canopy begins to close, the wildflowers of late spring take over. Wild geraniums form lavender seas. The trilliums flower: first bloody butcher with purple petals arching upward, then large white trillium, and then nodding

American Toad

Wild Ginger

trillium, petals stretching out from between the sepals. Flowers dangle like bells in the leaf axils of Solomon's seal and hairy Solomon's seal; their leaves resemble those of the false Solomon's seal and starry Solomon's plume, but the flowers of those species form bouquets at the tips of the stem. The understory burns with wild hyacinth.

V

Everything that was brightest and most beautiful in mid-May is overrun by the end of the month, as wild lettuce reaches to my knees and orchard grass stretches out along the road through the arboretum. The false mermaid I found the first week of March is yellowing and flattened like seaweed against a boulder, pouring its last into the nutlets ripening at its apex. The forest floor is a bed of jewelweed. Yellowing leaves of white trout lily and variegated leaves of toothwort and wild leek stand out in the darkening understory beside the last flowers of false rue anemone. The first flowers of great waterleaf open as the hairy, spiderlike inflorescence branches unroll atop the plants. Bloodroot leaves swell to the size of my hand with fingers fully outstretched and lay back to absorb what sunlight they can through the closing canopy.

Maple and elm seeds rain down overnight, clogging the gutters. Mayapple flowers become the lights of the woods, shining from beneath their great green umbrellas. For a week or so, I can hear golden-winged and black-and-white warblers, northern parulas, black-throated greens, all passing through, alongside the birds of summer: pewees and great-crested flycatchers, kingbirds, phoebes, gnatcatchers and red-eyed vireos, tanagers, ovenbirds, buntings, wood thrushes, and orioles. An olive-sided flycatcher calls an insistent "quick three beers!" Mosquitoes become pesky in the evenings. Spring peepers grow silent. American toads drone on.

The onslaught of spring has come to a close, that time when I see each plant from all sides and keep thinking, what will happen tomorrow? Because for a few weeks, everything is happening at once. No one could catch it all in one year. A person needs year after year in, ideally, a single forest to get the sequence straight.

* For more on the ecology, beauty, and importance of mosses, read Robin Wall Kimmerer's magnificent *Gathering Moss: A Natural and Cultural History of Mosses* (2003, Oregon State University Press).

PLANTS REFERENCED

Acer saccharinum – silver maple
Acer saccharum – sugar maple
Allium canadense – wild garlic
Allium tricoccum – wild leek
Arisaema triphyllum – Jack-in-the-pulpit
Asarum canadense – wild ginger
Atrichum altecristatum – wavy starburst moss
Camassia scilloides – wild hyacinth
Cardamine concatenata – cut-leaved toothwort
Carex albursina – white bear sedge
Carex pensylvanica – Pennsylvania sedge
Caulophyllum thalictroides – blue cohosh
Celtis occidentalis – hackberry
Claytonia virginica – spring beauty
Corylus americana – hazelnut; you may also have *C. cornuta* in your area
Dactylis glomerata – orchard grass
Dicentra cucullaria – Dutchman's breeches
Enemion biternatum – false rue anemone
Erythronium albidum – white trout-lily
Floerkea proserpinaca – false mermaid
Fragaria virginiana – strawberry; you may also encounter *F. vesca* as a common species in your area
Geranium maculatum – wild geranium
Geum canadense – white avens
Hepatica acutiloba, H. americana – hepatica
Hydrophyllum appendiculatum – great waterleaf
Impatiens capensis, I. pallida – jewelweed
Lactuca spp. – wild lettuces
Laportea canadensis – wood nettle
Maianthemum racemosum – false Solomon's seal
Maianthemum stellatum – starry Solomon's plume
Mertensia virginica – Virginia bluebells
Plagiomnium cuspidatum – baby tooth moss
Podophyllum peltatum – mayapple
Polygonatum biflorum – Solomon's seal
Polygonatum pubescens – hairy Solomon's seal
Rhamnus cathartica – buckthorn
Quercus macrocarpa – bur oak
Quercus rubra – red oak
Sanguinaria canadensis – bloodroot
Thalictrum dioicum – early meadow-rue
Thalictrum thalictroides – rue anemone
Trillium flexipes – nodding trillium
Trillium grandiflorum – large white trillium
Trillium recurvatum – bloody butcher
Viola sororia – wood violet

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How to See Urban Plants

Jonathan Damery

"Sight is a faculty; seeing, an art," the environmentalist George Perkins Marsh wrote in his 1864 treatise *Man and Nature.* "I know no more important practical lessons in this earthly life of ours—which, to the wise man, is a school from the cradle to the grave—than those relating to the employment of the sense of vision in the study of nature." Botanical field guides, which became increasingly popular around the turn of the twentieth century, aimed to support the art of seeing. Their authors promised to transform overlooked spaces into landscapes filled with interest. One of the first successful field guides for the northeastern United States was Frances Theodora Parsons's *How to Know the Wild Flowers,* which was originally published in 1893. In the introduction, Parsons attested that "even a bowing acquaintance with flowers … causes the monotony of a drive through an ordinarily uninteresting country to be forgotten in the diversion of noting the wayside flowers, and counting a hundred different species where formerly less than a dozen would have been detected."

Yet an individual field guide necessarily elevates certain plants over others. After all, the guide must be sized for a pocket or, perhaps more

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ALL PHOTOS BY PETER DEL TREDICI

Previous page: horseweed (*Erigeron canadensis*) and dandelion (*Taraxacum officinale*). Above: tufted lovegrass (*Eragrostis pectinacea*) and prostrate knotweed (*Polygonum aviculare*).

realistically, a backpack. One of the most provocative field guides to appear in recent years is Peter Del Tredici's *Wild Urban Plants of the Northeast* (Cornell University Press), which presents an expansive vision for which plants, not to mention which landscapes, are worthy of being seen. The second edition was published this spring, adding forty-five plants to the two-hundred-plus included in the 2010 edition. Del Tredici, who is an emeritus research scientist at the Arnold Arboretum, has provided, among other things, photographic documentation of the overlooked plants that inhabit overlooked urban places. In cities like Boston, New York, and Philadelphia, the plants are often so common that they are inconspicuous, ubiquitous but unseen. Del Tredici shows riverbank grape (*Vitis riparia*) cascading from powerlines in an alleyway and prostrate knotweed (*Polygonum aviculare*) trapping cigarette butts on a sidewalk. These are common scenes that urban commuters and pedestrians often pass without a second thought.

Almost half of the species that are newly added in the second edition are North American natives, including familiar trees like the black walnut (*Juglans nigra*). These additions suggest the haziness inherent to determining whether something should be included or excluded from any field guide—even one, like Del Tredici's, that is emphatically inclusive. Del Tredici describes the black walnut as an ornamental shade tree from a bygone era. Its spread into neighboring lots may seem unremarkable; the trees are almost too normal to be noted. The same goes for the green ash (*Fraxinus pennsylvanica*), which was another new addition. Deciding which plants should be featured in a field guide necessarily requires parameters. Parsons, in 1893, described her intention of omitting plants that were "so common as to be generally known" and "so inconspicuous as generally

Riverbank grape (*Vitis riparia*) crosses over a Detroit alleyway, and maintenance crews would surely love to remove this American elm (*Ulmus americana*) in Hartford.

to escape notice." Del Tredici, meanwhile, draws lines pertaining to the definition of the term *urban* and, by extension, a distinction between the spontaneous and the cultivated.

The most fascinating photographs in the book are those that show the plants within their urban milieu. After all, as Del Tredici writes in the introduction, "it is the context in which the plant is growing—not the plant itself—that makes it a weed." Within these landscapes, the plants often appear uncontained; they have an agency unto themselves. Road markings are a frequent motif in the photographs, and Del Tredici captures the omnipresent dandelion (*Taraxacum officinale*) sandwiched between a left turn lane and the oncoming traffic, as though the plants were moving in flagrant disregard of the yellow centerlines. He shows an American elm (*Ulmus americana*) flattening itself against a chain-link fence, in Hartford, Connecticut, where it has been hacked back repeatedly. The photographs document a changing landscape, one caught in an ongoing state of becoming.

The book includes more than one thousand of Del Tredici's photographs, and in the opening pages, he notes that many were taken on family trips and errands. He acknowledges his family's patience with "sudden stops on the side of the road" for "yet another 'weed' picture." In this sense, the photographs are remarkable in that they document not merely the fact of the plants but also the fact of stopping for them—the fact of pulling over to the side of the road, as other cars zipped past, and hopping onto the shoulder to actually observe the plants up close. The book, in other words, is a testament to the necessary art of seeing.

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Spring is the New Fall

Kristel Schoonderwoerd

When we welcome new foliage in the spring, we must also bid adieu to another set of structures that have adorned trees throughout the winter: the bud scales. That's right, May is the perfect time for bud-scale peeping, and there is no finer tree to start with than the shagbark hickory (*Carya ovata*), a Massachusetts native. With its finger-like leaflets pointing towards the sky, emerging from a skirt of magenta scales, the spring shoot of a shagbark hickory is reminiscent of an alien that has recently taken up flamenco dancing. A large grove of shagbark hickories (accession 12907) can be observed near the Centre Street entrance to the Arnold Arboretum, and for an observant spring enthusiast, the spectacular display is likely to turn an easily overlooked piece of botany into a pressing question: What are these pink structures?

Buds scales are best known for their winter protective role. Trees repeatedly develop new organs (leaves) throughout their lifetimes, but this mode of continuous development can be challenging in a temperate climate. In the words of John Muir: "Consider what centuries of storms have fallen upon [trees] since they were first planted,—hail to break the tender seedlings; lightning, to scorch and shatter; snow, winds, and avalanches, to crush and overwhelm,—while the manifest result of all this wild storm-culture is the glorious perfection we behold." Bud scales are one item in a long list of adaptations that make this glorious perfection possible, and not an insignificant one. Bud scales envelop the sites where new leaves are initiated. Newly formed miniature leaves, waiting for spring, are thus provided with a sheltered space for their earliest development.

As the leaves mature within the bud scales, their familiar form, comprising a leaf blade, a leaf stalk, and a leaf base (the attachment point of the leaf to the stem), begins to appear. To understand what bud scales truly are, in addition to what they do, we have to follow this closely coordinated chain of leaf development even further back to when the scales themselves were first formed. Bud scales are, in fact, leaves—modified leaves, never meant to capture light over the growing season. When a tree builds a bud scale, it makes a leaf with just a long and thin version of a leaf base and none of the other components. We know this because vein patterns in the base of certain photosynthetic leaves are similar to those in bud scales. In addition, if you look at a lot of bud scales, and you are lucky, then you might find a happy accident where a leaf has ended up half bud scale and half foliage leaf, indicating the relatedness between the two forms. Moreover, we know that bud scales and photosynthetic leaves are initiated in the same pattern, from the same cell clusters.

New bud scales appear relatively early in the season for shagbark hickories. In fact, if you examine the tender stems that emerge with the fresh leaves in the spring, you can already see the very earliest, minute instances of the new bud scales—including the pink flamenco dresses of the following year. This way, the growing tips are not only protected during winter but are never once exposed through the four seasons.

It follows that the conspicuous pink phase in early May is but the swan song of the shagbark hickory's bud scales. After many months of passive sheltering, the scales start to rapidly expand and change color in the spring. The reddish color may well point towards a continued protective role. These blushes are caused by anthocyanins, the very same compounds that color leaves red or purple in the fall. The currently most-favored hypothesis states that anthocyanins function as a sunscreen, protecting delicate structures—new, growing leaves in this case—from excess sunlight. Perhaps the spring metamorphosis observed in the shagbark bud scales is a final act to guard the small but rapidly expanding leaves, until the leaves can grow and function without outside protection and the scales can drop away, no longer needed, and make way for the next cohort.

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